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COMPARING THE EFFICIENCIES OF STATE TRANSPORT UNDERTAKINGS OF INDIA USING DATA ENVELOPMENT ANALYSIS

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ABSTRACT

This paper compares the performance of the State Transport Undertakings of India using Data Envelopment Analysis (DEA). This non-parametric approach of efficiency evaluation is based on piecewise linear frontiers estimated with the help of mathematical programming techniques. DEA is used to evaluate the technical, pure technical, scale and managerial efficiencies. Weight flexibility is a major drawback in using DEA, hence, weight restrictions have been introduced in the DEA models. To give a meaningful ranking structure, an average normalized score has been computed for all the units under study. The analysis has shown bus companies with clear differences in their productivity.

KEYWORDS: Data Envelopment Analysis, Linear Programming, Efficiency Measurement, Weight Restrictions, Normalized Scores, Ranking

1. INTRODUCTION

Intensification of the economy of any nation has become inevitable today. The fluctuations in the financial market and recessions in the jobisshunting the economic growth. Developing economies are to a certain extent dependent on the economies of the developed nations. However, there is a better scope of development in such economies in spite of a grave global financial market.

The stability of any growing economy is dependent on all itseconomic sectors. These sectors have to be self sufficient. The steadiness in these sectors is on the other hand dependent on the mobility of people to and from their place of work. The road and transport network thus becomes a strong foundation for a stronger economy. The efficiency of the transportation system enables growth and productivity. Transportation being a factor in almost all other economic activities makes this sector a revenue generator sector.

India has a large and extensive transportation system. The country has one of the world’s largest roadways network transporting millions of people every year.Growing economy has led to a rapid increase in urbanization. People are migrating to urban areas due to lucrative job opportunities. The existing cities are stretching their boundaries to accommodate this increase in population. The hubs for economic activities, university campuses and industries are growing rapidly and hence are generating more jobs. Thus, there is a strong need to make these places of employment generation more accessible. The dynamic changes in life and work have increased the importance of Transport sector in India.

Motorized transportation is the best available means for this purpose. A good public transport system is therefore considered to be a strong backbone for the development of any economy. In the absence of such a system, the dependency on personalized modes of transport increases. This is nothing but energy extravaganza. The environmentalists are working hard to reduce carbon footprints. Scientists are looking for solutions in terms of optimal utilization of natural resources. Hence, the operators or the authorities handling public transport systems are trying their level best to provide quality services to their customers. The managers of these companies have tried out infrastructural changes in terms of changing

the technology or the fuels for their buses. The need now is to look for managerial solutions so that efficient and quality services are provided to the consumers.

The basic fundamental principle of quality is-"Anything that cannot be measured, cannot be improved". Thus, improvements in the services can only be made only when the managers are made aware of their weaknesses. Benchmarks should be made available to the service providers so that they can self evaluate themselves in comparison to their competitors.

2. BACKGROUND

Public transportation in India is provided by State Road Transport Undertakings (STUs) within each state and union territory of India. Every state runs its own bus companies which mainly cater to its internal transportation needs and connecting the cities to other states. Typically, every state owned bus company is named "state name" State Road Transport Undertaking. There are 44 such STUs in India, out of which 18 are run by private operators. The remaining are either corporations or are run by government departments.

There is a constant pressure on these companies to improve their performance. Consequently, the operators are more concerned to study their efficiency levels in comparison to their competitors. The managers of the companies are looking for a crisp and concrete analysis of their performances. They need concise suggestions to improve their efficiencies.

Conventional studies to measure the performance of transport sector have been based on cost ratios, estimation of average cost functions and other econometric methods. Index number approach and regression analysis has also been used to estimate their growth and levels of productivity for the STUs in India [14]. However, these methods have their own limitations. These methods are concerned more with the specific economic aspects and less with efficiency measurements. Moreover, in the case of multiple outputs or inputs the results of these methods yield varying results. Data Envelopment Analysis is a non-parametric technique for evaluating the relative efficiency of a set of homogeneous decision making units by using a ratio of the weighted sum of outputs to the weighted sum of inputs. It is a frontier based approach rather than the conventional average approach for efficiency evaluations. A best practicing frontier is defined from the data set and the efficiencies are measured relative to that frontier. Thus, this method is best suited for measuring the efficiencies of bus operators because-

- Simultaneous analysis of multiple outputs and multiple inputs can be done.
- No explicit production function is required.
- It has a frontier based approach rather than the central tendency approach.

DEA has been used to estimate the efficiency of schools [1], hospitals [15], banks [19], railways [7], computers and peripheral firms [4] and transport sector [13]. However, in India, the studies based on DEA are relatively few. Ramanathan [16] has mentioned all in his monograph. Bhatt et al [2] have applied DEA to assess the performance of health care services, Kumar and Verma [12] have used it in public sector banks.

A number of applications of DEA in transportation systems is available in the literature. Karlaftis [11] uses DEA as part of a methodology to assess the efficiency of transit operators. Pina and Torres [14] used DEA to compare the efficiency of public and private transit operators. Odeck and Alkadi [13] studied the efficiency in the Norwegian bus industry using DEA, Ji Han etal [10], have used DEA to evaluate the efficiencies of China's Public transport systems.

The present paper focuses on analyzing the performance of Indian bus companies using DEA. In the third section, basic DEA models have been discussed. The methods to compute TE, PTE, WTE, SE and ME have been discussed. The method used to impose restrictions on the weights of the CCR model has also been discussed. In order to give a meaningful ranking structure to the units under study, average of the normalized scores of all the efficiency measures discussed in the paper have been computed and then the units have been ranked. Section4 discusses variables chosen for the analysis. A descriptive analysis of the input and the output variables have been elaborated in this section. Section 5 summarizes the analysis carried out in this paper.

3. THE DEA METHODS

3.1 The Basic DEA Models

Data Envelopment analysis or DEA as it is commonly called, was put forth by Farrell in 1957 [6] and extended by Charnes, Cooper and Rhodes in 1978 [3]. It was initially used to evaluate and compare the efficiencies of non-profit organizations whose performance cannot be measured on the basis of profits.

The frequently used models of DEA are the CCR (Charnes, Cooper and Rhodes) and BCC (Banker, Charnes and Cooper). In the CCR model, the frontier is spanned by the linear combination of the units in the data set. The efficiency scores obtained from this model are known as technical efficiencies (TE). These scores reflect the radial distance from the estimated frontier to the unit under consideration. A score less than unity amounts to inefficiency in that unit. When the unit has an efficiency score less than one, then there must be at least one unit in the data set which is efficient with a score of unity. The set of such units is called as the reference set or the peer group for the inefficient unit. There are two ways to obtain efficiencies. The inputs can be minimized while satisfying at least the given output levels. This is called the input oriented model. The output, on the other hand, can be maximized without increasing the observed inputs. This is called the output oriented model. The CCR model is based on the assumption of constant returns to scale (CRS).

In the BCC model, the frontier is spanned by the convex hull of the units in the data set. The frontier in this model thus have piece-wise linear and concave characteristics. The efficiency scores of this model are known as pure technical efficiencies (PTE). It is based on the variable returns to scale (VRS) assumption. But, from both the models, a unit is inefficient if it is possible to reduce any input without increasing any other inputs and achieve the same levels of outputs or it is possible to increase any output without reducing any other outputs and use the same levels of inputs. The ratio of the technical efficiencies to that of pure technical efficiencies i.e. TE/PTE is called the scale efficiency of that unit.

Mathematically, the CCR model can be described as-

Consider a set of *n* units, each operating with *m* inputs and *s* outputs, let y_{rj} be the amount of the *rth*output from unit *j*, and x_{ij} be the amount of the *ith* input to the *jth*unit. According to the classical DEA model, the relative efficiency of a target unit j_0 is obtained by maximizing the ratio of the virtual output to the ratio of the virtual input subject to the condition that this ratio is less than unity for all the units of the data set. Thus, the objective is to

$$\max h_{j_0}(u,v) = \frac{\sum_{r=1}^{s} u_r y_{rj_0}}{\sum_{i=1}^{m} v_i x_{ij_0}}$$

subject to

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1, \qquad j = 1,2,\ldots,n$$

$$\frac{u_{rj_0}}{\sum_{i=1}^{m} v_i x_{ij}} \geq \varepsilon, \qquad r = 1,2,\ldots,s \tag{1}$$

$$\frac{v_{ij_0}}{\sum_{i=1}^{m} v_i x_{ij}} \geq \varepsilon, \qquad i = 1,2,\ldots\ldots m$$

The decision variables $u = (u_1,.., u_r,., u_s)$ *and* $v = (v_1,., v_i,., v_m)$ are respectively the weights given to the *s* outputs and to the *m* inputs. To obtain the relative efficiencies of all the units, the model is solved *n* times, for one unit at a time. Model (1) allows for great weight flexibility, as the weights are only restricted by the requirement that they should not be zero (the infinitesimal ε ensures that) and they should not make the efficiency of any unit greater than one.

The fractional model (1) is solved as a linear program by setting the denominator in the objective function equal to some constant, say, 1 and then maximizing its numerator, as shown in the following model:

$$\max h_{j_0} = \sum_{r=1}^{s} u_r y_{rj_0}$$

subject to (2)

$$\sum_{i=1}^{m} v_i x_{ij_0} = 1$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0, \qquad j = 1,\ldots,n$$

$$u_r, v_i \geq \varepsilon \qquad \forall r, i$$

Thus, the objective is now to maximize the virtual output of the target unit subject to the condition that virtual output cannot exceed virtual input for every other unit. Technical Efficiencies (TE) are obtained from this model.

The BCC model is the dual of the CCR model along with an additional convexity constraint. Mathematically, the BCC model is-

$$\min\ z_{j_0} = \theta_{j_0} - \varepsilon \sum_{r=1}^{s} S_{rj_0}^{\ +} - \varepsilon \sum_{i=1}^{m} S_{ij_0}^{\ -}$$

subject to

$$\sum_{j=1}^{n}\lambda_{jj_0} y_{rj} - S_{rj_0}^{+} = y_{rj_0}, \qquad r = 1,2,\ldots,s$$

$$\sum \lambda_{jj_0} x_{ij} + S_{ij_0}^{-} = \theta_{j_0} x_{ij_0}, \qquad i = 1,2,\ldots,m$$

$$\lambda_{jj_0} \geq 0, \qquad j = 1,2,\ldots,n$$

$$\sum_{j=1}^{n}\lambda_{jj_0} = 1$$

$$\theta_{j_0}, \textit{unrestricted in sign}$$

$$S_{rj_0}^{+}, S_{ij_0}^{-} \geq 0 \quad r = 1,2,\ldots,s;\ i = 1,2,\ldots,m$$

where $S_{rj_0}^{+}$ is slack in the r^{th} output of the target unit, $S_{ij_0}^{-}$ is slack in the i^{th} input of the target unit, λ_{jj_0} are non negative dual variables and θ_{j_0} is the reduction applied to all inputs of the target unit to improve efficiency. This reduction is applied simultaneously to all inputs and results in a radial movement towards the envelopment surface.

In the BCC model, the convexity constraint represents the returns to scale. Returns to scale reflects the extent to which a proportional increase in all inputs increases outputs. The efficiency scores thus obtained are called as the Pure Technical Efficiencies (PTE)

Scale efficiencies (SE) are the ratio of the efficiency scores of the CCR and BCC models. All three efficiency scores are bounded by zero and one.

Managerial efficiencies (ME) can also be computed using the scores of BCC models. Sometimes, the less efficient units show productivity discrepancies when they are compared with the units that are more-efficient. This could be due to the organizational or technological drawbacks in those units. These discrepancies can be measured by computing the managerial efficiencies. Let PTE (Full Set) represent the efficiency scores of full set of units under study and let PTE (Sub Set) represent the efficiency scores of the subset of the less efficient units in the data set. The ratio of these scores is called as the managerial efficiencies.

$$ME_k = \frac{PTE_k(Full\ Set)}{PTE_k(Sub\ Set)}$$

3.2 Weight Restrictions

The CCR model of DEA computes the weights of the input and output variables with the objective of projecting that unit in the best possible light. This actually becomes a weakness of the model because some of the inputs or output variables get a very small weight which is practically not possible. Recently, a lot of research has been done to overcome this weakness of the DEA model by imposing restrictions on the weights. However, imposing bounds on factor weights limits the flexibility of DEA in assigning individual sets of weights to each of the units in the data set. When no flexibility is allowed a set of common weights can also be used for the assessment of the units. Several methods have been developed to find this set of common weights as given by Hosseeinzadeh [8], Roll et al [17] and Jahanshaloo et al [9] etc. The problem with these methods is the non linearity of the models. Saati [18] in his literature has developed a method that not only imposes bounds on the factor weights but also retains the linearity of the model.

In this technique, an upper bound for each factor is first determined by solving a linear programming problem. A common set of weights is then determined by compacting the weight intervals via solving another linear programming problem. To determine an upper bound on the weights, the following problems are considered

$$\begin{aligned}
&Max.\, u_r \\
&subject\ to \sum_{i=1}^{m} v_i x_{ij} \le 1 \qquad \forall j \\
&\qquad \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0 \quad \forall j \\
&\qquad v_i, u_r \ge 0 \qquad \forall i, r.
\end{aligned}$$

It has been proved that these problems are feasible and their optimal values are bounded and positive. Moreover, since $\sum_{r=1}^{s} u_r y_{rj} \le 1$, therefore, the upper bounds of input and output variables can be computed as

$$u_r^* = \frac{1}{\max(y_{rj})}\, 1 \le j \le n, \ \ (r = 1,2,\ldots.,s).$$

$$v_i^* = \frac{1}{\max(x_{ij})}\, 1 \le j \le n, \ (i = 1,2,\ldots.,m)$$

A common set of weights is obtained by solving the linear program

$$\begin{aligned}
&Max\, \phi \\
&subject\ to \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0, \ \ \forall j, \\
&\phi U_r \le u_r \le (1-\phi) U_r \qquad \forall r, \\
&\phi V_i \le v_i \le (1-\phi) V_i \qquad \forall i,
\end{aligned}$$

Where U_r (r=1,2,…s) and V_i (i=1,2,…m) are calculated as discussed above. It has also been proved that the problem is feasible and its optimal value is bounded and positive.

The common set of weights are used to compute the efficiencies of each unit in the data set by computing the ratio

$$h_j = \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \quad \forall j$$

In case none of the unit turns out to be efficient, all output weights are increased by minimal proportion of $u_r^{'} = \frac{u_r^*}{e}$ where e=max(h_j) for all j. These new set of weights are again used to compute the efficiency ratios. Till at least one unit turns out to be efficient.

1. METHODOLOGY

4.1 Data and Variables

The State Transport Undertakings in India are run either by government departments or Municipal undertakings or corporations or by private operators. In order to have a homogeneous data set, private operators have been excluded from the study. Also some of the undertakings did not have the complete data, so only 26 Public Transport Undertakings have been considered in this study. In order to have meaningful interpretations of the efficiency scores, an average unit has been constructed by taking the average of all the input and output variables and then studying it as an individual decision making unit along with the rest of the data set. The data has been collected for the year 2009-2010 [5].

Since DEA yields a relative efficiency measure and defines a unit inefficient by comparing combinations of input and output with other units, caution is necessary for using this technique. In order to make sufficient discrimination between the units of the data set, sample size should be at least three times the sum of input and output variables. Due to this, some of the variables have been merged together. For example, total staff has been considered by combining the staff on the road and the administrative staff.

Three variables have been identified as the input variables namely, the Fleet Size (FS), Total Staff (TS) and Fuel Consumption (FC). Technically, the inputs should include both capital and labour elements. Fleet size and fuel consumption represent the capital elements and total staff represents the labor element in the study.

Two variables, namely the passenger-kilometers (PK) and seat-kilometers(SK) have been taken as the output variables. The passenger-kilometer measures the annual production of the units under study.

The descriptive statistics of these variables are given in Table-1 below:

Table 1: Descriptive Statistics of the Variables

Variables	Maximum	Minimum	Average	Standard Deviation
Fleet size	21255	62	4045.5	4921.022
Total staff	115898	344	22422.08	27967.58
Fuel consumption	5249.2424	6.153	923.9977	1200.7277
Passenger Kilometers	974778	543	158696.4	132.4242
Seat Kilometers	1417673	913	233374.6	314639

A relationship amongst the input and the output variables was measured. Table-2 below shows that the output and the input variables are strongly correlated. Thus, the cause and effect relationship of the variables has not been violated during the period of study.

Table 2: Correlation between the Input and the Output Variables

Input / Output	Fleet Size	Total Staff	Fuel Consumption
Passenger kilometers	0.9817	0.9512	0.9896
Seat kilometers	0.99	0.9601	0.995

Since, the paper deals with the analysis of efficiency scores between the Public Transport Undertakings, and the two output variables are passenger kilometers and seat kilometers, the output maximizing models of DEA are used for efficiency evaluations. The technical efficiencies (TE) using CCR model, the pure technical efficiencies (PTE) using BCC model, the scale efficiencies (SE), the managerial efficiencies (ME) and the efficiencies by using the weight restrictions,

called as the weighted technical efficiencies (WTE) have been evaluated for the data set of 27 units including an average unit.

2. ANALYSIS OF THE RESULTS

2.1 Technical Efficiencies

Out of the 27 units under study, only 7 of them (26% of the data set) were seen to be technically efficient with their PTE scores equal to 1. However, this group of the data set contributes to only 42% of the total annual production. The inefficient units are responsible for the remaining 58% production. Out of these 7 units, two are observed to have their TE scores less than 1. This means that these two units need to improve their scales of operation.

Also, 7 of the units had their PTE score lying in between 0.62 to 0.74. They are the set of the least efficient units. Five of these seven transport undertakings are of the major metropolitan cities of India. Their contribution to the annual production is observed to be only 12%. This fact should be conveyed to the managers of these undertakings. The metropolitan cities are a major hub for employment generation in India. An efficient public transport system in these cities would solve a lot more related problems as well. At present, in the absence of an efficient and a reliable public transport system, people prefer using their personalized modes of transport. This not only leads to traffic congestions but also is a major cause of pollution. An improvement in this sector would reduce the carbon foot print and increase the annual production of the transport sector of India.The summary statistics of these efficiency scores is given in Table-3 below.

Table 3: Summary Statistics of the TE and PTE Scores

Scores	No. of Efficient Units	Minimum	Maximum	Average	Standard Deviation	Average Unit
TE	5	0.456	1	0.819	0.15	0.8413
PTE	7	0.62	1	0.873	0.13	0.99

The average unit was observed to be operating on increasing returns to scale. Five of the units were observed to be operating on decreasing returns to scale.

2.2 Scale Efficiencies

Scale efficiencies are computed by taking the ratio of the CCR and the BCC scores. A statistical summary of SE is given in Table-4. The average SE is 0.938 which is quite high. For five of the units in the data set, the PTE scores are observed to be higher than their SE scores. This means that the inefficiency in these units is due to scale inefficiency. These units need to improve their scales of operation. However, care must be taken in improving their scales, because these units also cater to the rural areas. Thus, their social cause may be lost in changing their scales of operation. However, policies can be reframed for these units so that the efficiencies are improved. The remaining units on the other hand have technical inefficiencies. These units need to utilize their resources so as to improve their productivity.

Table 4: Summary Statistics of the SE Scores

Scores	No. of Efficient Units	Minimum	Maximum	Average	Standard Deviation	Average Unit
SE	5	0.456	1	0.937	0.12	0.998

2.3 Managerial Efficiencies

As explained in section 3.1, managerial efficiencies (ME) are computed by taking the ratio of the BCC scores of the subset to that of the full set. Five of the inefficient units show a ME score close to 1. This means that these units can reach the efficiency frontier more confidently in comparison to the other units. Also, the units that show a low ME scores are the same units that were technically the most inefficient units. Thus, the operators in these metropolitan cities must set up benchmarks to improve their efficiencies.

2.4 Weighted Efficiencies

The weight restrictions were applied to the variables as explained in section 3.2 and the efficiencies of all the units were computed by using a common set of weights. Only one unit was observed to be efficient for all the efficiency measures. This unit can be regarded as the best operating unit of the data set. Table-5 below gives a summary of the WCCR scores.

Table 5: Summary Statistics of the WCCR Scores

Scores	No. of Efficient Units	Minimum	Maximum	Average	Standard Deviation	Average Unit
WCCR	1	0.226	1	0.687	0.209	0.779

The WCCR efficiencies show more variation than the TE scores. In order to test the significance of the difference in the ranking procedure, Wilcoxon rank sum test was performed on the TE and WCCR scores. The difference was observed to be highly significant with a p-value of 0.0046. This shows that computing TE scores by applying weight restrictions gives more meaningful interpretations instead of computing only the TE scores. Similarly, the difference is highly significant for PTE and WCCR scores also with a p-value of 0.0006. However, this difference is not significant between the PTE and ME scores with a p-value of 0.6744. This shows that Managerial efficiencies give an insight into the scale operations of the data set under study.

Inorder to make the study meaningful, the scores of all the units for all the methods have been summarized in Table 6. An average score for all the units was computed by taking their normalized scores. This average score was then used to give a ranking structure for all the units.

Table 6: Scores and Ranking of the Units

S.No.	Units	CCR Scores	BCC Scores	SE Scores	ME Scores	WCC Scores	Average Scores	RANK
1	Andhra	0.946	1	0.946	1.029866	0.887983043	0.708933	9
2	Maha	0.745	0.838	0.889021	0.838	0.664166048	0.682275	16
3	Guj	0.943	0.976	0.966189	0.976	0.876265869	0.710597	8
4	UP	1	1	1	0.702247	0.921149076	0.731462	2
5	Raj	1	1	1	0.873362	0.951849724	0.725178	4
6	Kerala	0.695	0.705	0.985816	0.767974	0.667523033	0.679759	18
7	Karnatka	0.935	0.956	0.978033	0.956	0.883743569	0.711147	7
8	N w Kn	0.899	0.901	0.99778	0.929825	0.798755146	0.703879	10
9	N E KnRT	0.904	0.907	0.996692	0.928352	0.737354301	0.700833	12
10	PRTC	0.969	0.997	0.971916	0.997	0.890250858	0.712966	6
11	SETC(TN)	1	1	1	0.690131	0.881393695	0.729877	3
12	Bihar	0.596	0.704	0.846591	1.010043	0.248418944	0.624544	26
13	N Ben STC	0.649	0.678	0.957227	0.894459	0.433718785	0.651777	24
14	S Ben STC	0.76	0.834	0.911271	0.875131	0.628198591	0.680049	17
15	Kadamba	0.781	0.858	0.910256	0.94265	0.557364628	0.6746	19
16	Himachal	0.781	0.791	0.987358	0.925146	0.70393147	0.685141	15

Table 6: Contd.,

17	Orissa	1	1	1	0.865052	0.779048454	0.716096	5
18	**MEGTC**	**0.456**	**1**	**0.456**	**1.876173**	**0.226661077**	**0.570249**	**27**
19	BEST	0.619	0.62	0.998387	0.785805	0.55294697	0.661638	22
20	DTC	0.739	0.741	0.99730211	0.852704	0.481751245	0.668749	20
21	Bangalore	0.853	0.869	0.98588	0.889458	0.708532893	0.695379	14
22	Calcutta	0.639	0.671	0.95231	0.754781	0.380550537	0.653059	23
23	**MTC(CNI)**	**1**	**1**	**1**	**0.721501**	**1.000000077**	**0.734579**	**1**
24	Pune	0.698	0.706	0.988669	0.865196	0.513429822	0.665293	21
25	Chandigarh	0.909	0.998	0.910822	1.002008	0.793891115	0.701169	11
26	Kolhapur	0.665	0.999	0.665666	1.415014	0.597805534	0.641375	25
27	Average	0.84	0.8416	0.998099	0.918777	0.779021476	0.696804	13

It can be seen from the above table that the unit number 23 ranks the first in the average score ranking and in other methods as well. Thus, only this unit can be treated as the most efficient unit in this data set. However, even this unit has a potential improvement as it does not turn out to be the most efficient unit as per the ME scores. Similarly, unit number 18 has turned out to be the most inefficient unit by most of the methods. But a high BCC score and ME score clearly reflects that the operators in this area have no competition and thus they are exploiting the situation. The commuters in return are not gaining any benefit by these operations.

CONCLUSIONS

In this paper an efficiency analysis of the State Transport Undertakings that operate in the cities of India for the passenger road transport system have been done. Technical, scale, managerial and weighted efficiencies scores were computed by using the CCR and BCC models of Data Envelopment Analysis (DEA). The inclusion of weight restrictions was done with an aim to refine the analysis.

Increasing returns was observed in only six of the units, whereas five of the units were operating on decreasing returns to scale. For the bus companies, scale is a major reason for inefficiencies. The metropolitan cities of India have an important contribution in the growing economy of the country. By using appropriate levels of their inputs to produce appropriate levels of outputs, these cities can generate more revenue for the transport sector of the country. The objective is to sensitize the managers of the bus companies about their inefficiencies so that they can improve their services.

By applying weight restrictions, it was observed that the technical efficiencies are very low. This is an indicator of inefficiency in this sector. Moreover, this also indicates that the level of competition in this sector is also very low. When the competition gets high, low performers have no option but to improve or else they would be driven out. The policy makers have to be careful in allocating funds to this sector and must evolve a process of constant evaluation for this sector so that this sector becomes a revenue generating sector of Indian economy.

However, though the study in this paper is extensive but not exhaustive. Certain more variables need to be studied for a more detailed analysis such as density of the areas, network of the buses, safety parameters, and number of stoppages. This data is presently not available. It is intended to do more detailed analysis by taking these variables also under consideration. A benchmarking process would also be developed for the inefficient units by taking the efficient units as the reference set.

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